Drying Supplement May 2014

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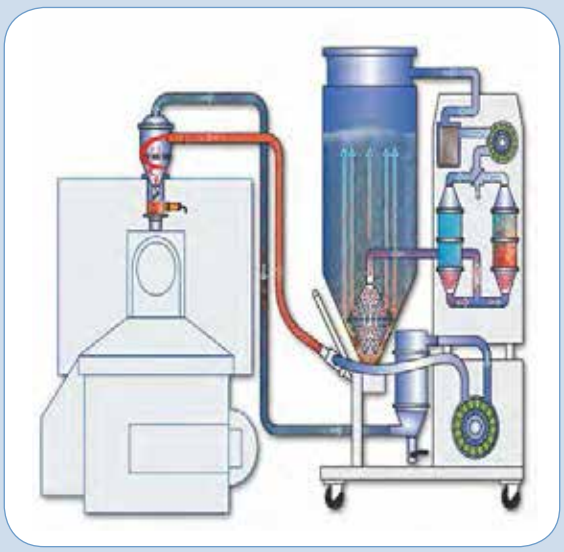
contents | May 2014

6 The Whys and Whats of Drying



DRI-AIR INDUSTRIES

In most plastics processing plants, resin dryers are a standard piece of equipment. Other than polyolefins, almost every other commercial polymer exhibits some level of polarity and therefore can absorb a certain amount of moisture from the atmosphere. Here's a look at some of these materials, and what needs to be done to dry them.

BY MICHAEL SEPE, MICHAEL P. SEPE LLC

12 How to Specify a Dryer

It's critical to dry moisture-sensitive resins correctly so they perform as intended in the field. For that you need a dryer that is properly designed and working correctly. Here are some guidelines on choosing a dryer and some reasons behind the recommendations.

BY JOHN BOZZELLI, INJECTION MOLDING SOLUTIONS

20 Raise the Bar on Drying

The processors speak: Here's how some savvy molders and extruders tackle the vexing problem of resin drying.

BY JAMES J. CALLARI, EDITORIAL DIRECTOR

ALSO IN THIS ISSUE

5 EDITORIAL: TIME TO SHED SOME LIGHT ON DRYING

32 BOZZELLI'S HANDY DRYING TIPS (AND QUIZ)

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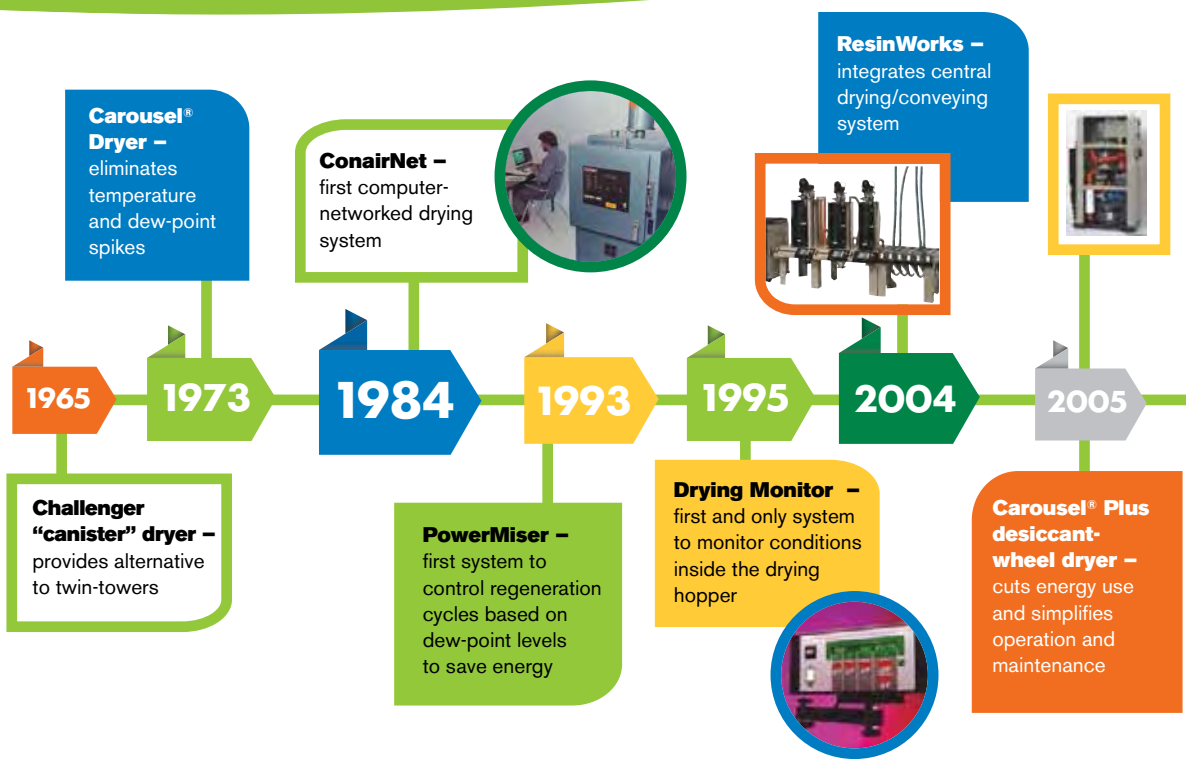
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1973
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2012

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2013

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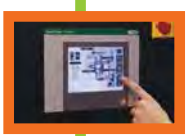

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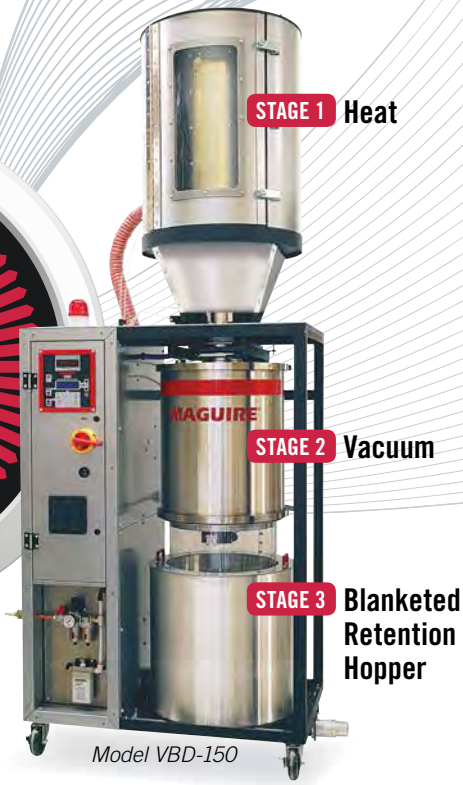

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editorial

by james callari

Time to Shed Some Light on Drying

It's probably way past time for a clearer understanding of this essential process by most processors. In

my 27+ years of plastics journalism, never have I come across a process that causes more consternation among processors than drying plastic pellets.

And, really, their problems with drying have nothing to do with any technological shortcoming. It's not as if "the thing" isn't working right. Quite the contrary, suppliers of dryers have advanced their technology to the same—if not greater—extent as any other equipment category. We're seeing more in the way of user-friendly controls, automated self-regulation, energy savings, flexibility, and just about everything else, than ever before.

Yet so many processors have had a problem with drying for years. I've heard that not just from equipment suppliers, but from the processors themselves. One put it to me this way: "You can have the best dryer that money can buy and still be bad at drying."

The problem with drying, I think, is more of a mindset. Nobody *wants* to be bothered with drying, but if you're running hygroscopic resins you have to. Lots of processors view drying as a necessarily evil, and getting them to think about it as seriously as some of their other processes can be challenging. Unlike, say, blending, which allows processors to develop formulations and recipes that improve the properties of their products and possibly the prices they can charge for them—no one *makes* money from drying. But you can certainly *lose* money by doing it wrong.

With those thoughts in mind, we bring you this supplement to the May issue of *Plastics Technology*, "Drying Done Right." In it, you'll find tips and advice from two of the industry's foremost experts in materials and processing: Mike Sepe and John Bozzelli. To regular readers of *Plastics Technology*, these should be recognizable names: Mike authors our monthly Materials Know How column, while John writes our Injection Molding Know How column.

Photo: Conair

Photo: Wittmann Battenfeld

Photo: ABS/ Moretto

Photo: Novatec

We also have a feature story in which processors who know their stuff about drying share their knowledge.

Finally, this supplement concludes with another Bozzelli contribution: a handy drying cheat sheet consisting of a dozen tips (and a quiz to boot). You ought to think of running to your photocopier and posting this checklist on a bulletin board in your plant, or near every piece of drying equipment you have.

We've intended this supplement to be "evergreen." Our goal was to present information that would be useful to you now as well as tomorrow, next month, and next year. We hope we've met this objective.

Happy drying. PT

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feature

by michael sepe, michael p. sepe llc

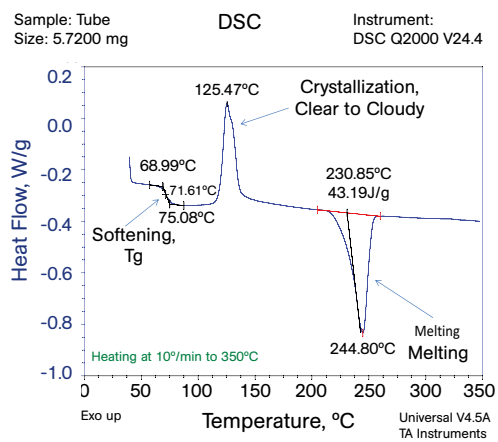
Why (and What) You Need to Dry

In most plastics processing plants, resin dryers are a standard piece of equipment. The notable exception to this would be facilities that exclusively process polyolefins such as polyethylene and polypropylene. These are among the few polymer families that do not require drying because these material families are not hygroscopic. Materials like polyethylene are non-polar, while water is a highly polar substance that acts like a small magnet with a negatively charged and a positively charged end. Water has no affinity for non-polar polymers. Exposing polyethylene or polypropylene to water is like placing oil in water. The two substances separate immediately because they have nothing in common chemically.

But almost every other commercial polymer exhibits some level of polarity and therefore is capable of absorbing a certain amount of moisture from the atmosphere. The amount of moisture that any given polymer can absorb depends upon the chemistry of the polymer and the atmospheric conditions to which it is exposed. Polymers such as blends of PPE and HIPS are only slightly polar and even at saturation can only hold 0.07% moisture. At the other end of the spectrum is nylon, a highly polar polymer that when taken to the point of saturation can absorb 8-9% water or over 100 times as much as PPE/HIPS compounds.

However, even moisture levels of 0.07% can cause cosmetic problems on a part surface if the material is exposed to the temperatures of melt processing. The resulting defect, known as splay or silver streaking, is an indicator that the material being molded contains too much moisture. Drying is a necessary preparative step to prevent this defect.

Agitate PET to Prevent Agglomeration



A DSC scan of PET bottle resin reveals that it goes through a glass transition, evident as a step transition in the thermogram, at around 70-75 C. At this point it will soften. When it reaches a temperature of about 110 C the polymer begins to crystallize. At 245 C these newly formed crystals melt. If the amorphous form of PET were heated from room temperature to the required drying temperature, it would agglomerate into one large mass and would then crystallize in that same large mass. To prevent this, PET must be constantly agitated while it is heated through its glass-transition temperature and its solid-state recrystallization. PLA exhibits similar behavior.

While many materials are dried solely to optimize surface appearance, some polymers undergo more significant changes if they are processed in the presence of too much moisture. These materials actually enter into a chemical reaction with the moisture—called hydrolysis. This mechanism breaks the covalent bonds in the polymer chain, reducing the molec-

ular weight of the polymer and potentially resulting in a significant reduction in mechanical properties.

Table 1 classifies polymers according to their behavior in relation to water. Hydrophobic materials cannot absorb any significant amount of moisture. Any moisture that could be present in these materials will remain on the surface of the pellets and seldom rises to a level greater than 0.01%, not enough to cause any cosmetic or structural problems.

On rare occasions there are reports of cosmetic defects in parts molded in polyethylene or polypropylene that are traced to excess surface moisture deposited due to rapid changes in the temperature and humidity of the plant. But these are usually easily rectified by simply allowing the raw material to come to equilibrium with the surrounding atmosphere so that the surface moisture can evaporate.

Hygroscopic materials break out into two subsets. One group experiences only cosmetic problems if not properly dried. Members of the other group suffer irreversible structural damage due to hydrolysis. Table 1 does not present an exhaustive list, but it includes many of the commonly used polymer families. It is also important to emphasize that blends need to be treated with the care required of the most sensitive polymer in the blend.

For example, a polycarbonate/ABS blend needs to be treated with the same care as polycarbonate. Sometimes seemingly subtle changes in formulation can change the importance of drying requirements. For example, it is generally considered unnecessary to dry acetals (POM); however drying is recommended for impact-modified POM because the impact modifier is typically polyurethane, which is subject to hydrolysis.

There are other important differences between the hygroscopic materials that exhibit only cosmetic defects and those that can degrade. With the exception of nylon, all the materials in the column with performance concerns must be dried to lower moisture contents than those materials with only cosmetic concerns.

Most of the polymers in the "Cosmetic Concerns" column can be successfully processed at moisture contents of 0.05-0.10%. However, the majority of the materials in the "Performance Concerns" column should not be processed at moisture

TABLE 1 Polymers' Interaction with Moisture

Hydrophobic	Hygroscopic: Cosmetic Concerns	Hygroscopic: Performance Concerns
Polyethylene	ABS	PET Polyester
Polypropylene	SAN	Polycarbonate
Polystyrene	Acrylic	Nylon
Butadiene-Styrene Copolymer	PPE/HIPS	PBT Polyester
Polymethyl-pentene	PPS POM PVC	Polyurethane Polylactic Acid (PLA) Polyimides (PEI, PAI)

levels higher than 0.02% and some of these materials achieve optimum properties when dried to levels as low as 0.005%. The optimum moisture level depends not only on the polymer but also on other processing parameters such as melt temperature and residence time in the molten state.

The type of process may also have an influence: Profile extrusion, for example, may require a lower moisture content than injection molding. Secondary operations such as plating or ultrasonic welding may also dictate a need for tighter control of the material's moisture content.

Proper drying requires attention to detail in the following areas: temperature and moisture content (dew point) of the inlet air, volumetric flow rate of the air across the pellets, time the material is in the drying hopper, and temperature of the return air coming back from the hopper to the drying unit. There are other areas of concern related to the design and maintenance of the system. This also assumes that a desiccant dryer is being used.

There are other methods, like vacuum and compressed-air drying. Other technologies such as infrared and radio frequency have been explored, but most commercial systems today still utilize some variant of desiccant technology. However, many systems still use hot air without the aid of a desiccant. While these systems are less complex, they lack the ability to consistently provide dry air to the material in the hopper.

Most material suppliers make specific recommen-

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dations for drying times, temperatures, and the dew point of the air being supplied to the drying hopper. Commonly recommended dew points fall between -20 and -40 F. These levels can be achieved only by passing the inlet air over or through a drying medium (desiccant or membrane filter). Otherwise, the dew point of the air will be whatever it is in the plant. On winter days in cold climates this number might be as low as 0 F, but on hot, humid days it can rise to 70-80 F.

At these conditions it is not possible to bring the moisture content of a raw material down to the levels required for the "Performance Concerns" group in Table 1, regardless of how long the drying process may be. It should be understood that much of the plastics material processed in Asia is not dried in desiccant systems and a significant amount of that material falls into the "Performance Concerns" category.

The conditions for effective drying are dictated to a significant extent by the polymer being processed. An elevated drying temperature is desirable since it increases the rate of moisture removal. However, the drying temperature must remain below the softening or melting point of the material. This is more likely to be a problem in amorphous materials, where the recommended inlet air temperature may be reasonably close to the softening point, or glass transition temperature, of the material.

Table 2 compares recommended drying temperatures with the softening or melting points of some commonly used polymers. It can be seen that for amorphous materials like ABS, polycarbonate, and acrylic, the difference between the drying temperature and softening temperature is relatively small. Anyone who has spent time in a molding plant has likely experienced the unpleasant consequences of a temperature override in a dryer when working with these materials.

The rules become a little more complex for polymer families where softening temperatures vary as a function of composition. One example is PPE/HIPS alloys. Grades with a high polystyrene content may have softening temperatures as low as 190-200 F and must be handled more carefully than high-PPE grades where the softening point may be as high as 330-340 F. Similarly, elastomers such as TPUs will exhibit a range of softening temperatures related to the Shore hardness of the grades.

TABLE 2 Comparison of Drying & Softening/Melting Temperatures

Polymer	Drying Temp., F	Softening Temp., F
ABS, SAN, ASA	170-180	200-220
Acrylic	170-180	200-220
Polycarbonate	250	290
Polyetherimide	300	410
PBT Polyester	250	420
Nylon	180	320-600
PPS	300	530

It may appear from the table that semi-crystalline materials like nylon and PBT polyester offer an opportunity to use much higher temperatures than are recommended. However, with these materials the potential exists for oxidation, a chemical reaction that can damage the polymer irreparably before it ever reaches the feed throat of the machine. This is particularly a concern for nylons.

PET, PLA: SPECIAL STEP REQUIRED

There are two materials in Table 1 where special steps are required during the drying process. These are PET polyester and PLA biopolymer (also a polyester). These materials go through a change from amorphous to semi-crystalline before ultimately melting. Figure 1 shows a DSC (differential scanning calorimetry) scan for the PET used to make beverage bottles. It goes through a glass transition, which appears as a step transition in the thermogram, at approximately 70-75 C (160-170 F). At this point it will soften.

However, when it reaches a temperature of about 110 C (230 F) the polymer begins to crystallize. If the sample could be viewed during this process you would see the material turn from transparent to cloudy and then opaque. This process is complete by the time the temperature reaches 140-150 C (285-300 F) depending upon the grade of material.

Finally, at a temperature of 245 C (473 F) these newly formed crystals melt. PET requires a drying temperature range of 135-165 C (275-330 F) and I have seen temperatures as high as 180 C (356 F) utilized in an effort to optimize performance. If the amorphous form of PET were heated from room temperature to

the required drying temperature, it would agglomerate into one large mass and would then crystallize in that same large mass at temperatures high enough to ensure effective moisture removal.

To prevent this, PET must be constantly agitated while it is heated through its glass transition temperature and its solid-state recrystallization so that it can then be heated to the appropriate drying temperatures without agglomeration. PLA exhibits essentially the same behavior, although the specific key temperatures are somewhat lower than they are for PET. And the stakes are very high for both polymers. Moisture levels as low as 50 ppm may be required in order to successfully process the material into product that has the desired properties.

This brings us to discussion of the real object of resin drying: moisture removal. There are a lot of parameters in the drying process that are monitored, but the actual moisture content of the dried resin entering downstream processing is really the only thing that matters. Many material suppliers provide guidelines for the moisture content that their resins must have to ensure good property retention. The problem for the industry is that very few processors measure moisture content.

A majority of processors simply follow drying guidelines or their best interpretation of them and assume that this is sufficient. Many processors incorrectly believe that if a material is processed with excessive moisture the parts will exhibit cosmetic defects.

A small percentage of processors employ a device that measures moisture content as a loss in total weight of a sample heated to a particular temperature for a prescribed time period. Unfortunately, these instruments measure all of the volatiles that evolve from the sample. They cannot distinguish between moisture and all of the other volatile constituents that may be in the material. A much small-

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er group of processors use an instrument that is sensor based and therefore is moisture specific. This is an appropriate strategy and results in processes that are much more reliable and less likely to produce parts with reduced mechanical performance.

But the best approach involves making accurate moisture measurements in the drying hopper. This has become possible within the last two to three years using measurements of dielectric properties in real time. There is a well-defined relationship between the moisture content of a polymer sample and these dielectric properties. This bypasses the need for off-line measurements conducted in the laboratory and allows for continuous real-time documentation of the only parameter that matters. In addition, the monitor can be interfaced with the dryer controls to regulate the drying conditions. This potentially saves energy and can prevent oxidation of the polymer and corresponding damage to the additives.

We can hope that this is the new face of resin drying. While no systematic studies have been performed to assess the lost time and money associated with substandard drying practices, it would be reasonable to estimate that it totals in the billions of dollars annually worldwide.

Improvement begins with an awareness of the shortcomings of current methods and practices. Once they are understood, greater knowledge of the myths and science associated with resin drying can be gained and many of the product failures that are experienced every year can become a thing of the past. PT

ABOUT THE AUTHOR

Michael Sepe is an independent materials and processing consultant based in Sedona, Ariz. with clients throughout North America, Europe, and Asia. He has more than 35 years of experience in the plastics industry and assists clients with material selection, designing for manufacturability, process optimization, troubleshooting, and failure analysis. Contact: (928) 203-0408 • mike@thematerialanalyst.com.

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feature

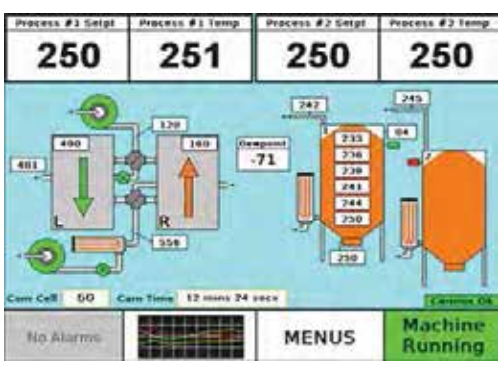
by john bozzelli, injection molding solutions

Bozzelli's Guide To Specifying A Dryer

Size a dryer a little larger than your estimated throughput to ensure plenty of time for adequate drying. (Photo: Dri-Air Industries)

It is critically important to dry moisture-sensitive resins correctly so they perform as intended in the field. For that you need a dryer that is properly designed and working correctly. Here are my suggestions on choosing a dryer and some reasons why.

1. **Size it to the quantity of material needed in lb/hr.** I would tend to go a little larger than your estimated throughput. The polymer actually binds the water to itself to some extent and you need time for the heat to penetrate through all the granules.
2. **You'll need temperature readouts:**
   a. *At the inlet of the drying hopper.* You need to know that the hose to the hopper is not leaking or losing too much heat because of lack of insulation. The temperature at the inlet should be at the resin manufacturer's suggested drying temperature.
   b. *At the outlet of the drying hopper.* You also need to know that the air temperature coming out of the hopper is not too low. This cannot and should not be the same as the entry temperature, but if the loader gasket is leaking (as they often do) you may be pulling in room air and that will give you a low temperature reading. I am comfortable with a reading 40° F (20° C) higher than the room temperature.



Make sure you have air-temperature sensors at critical points in the drying process. A dewpoint monitor is also useful. (Photo: Universal Dynamics)

Desiccants have an optimum temperature range to perform their drying function. You should have a sensor to monitor the air temperature to the desiccant. (Photo: Novatec)

Make sure your regeneration heaters are working properly by monitoring the heater amps or resistance (ohms), or the temperature of the air going to the desiccant for regeneration. (Photo: Universal Dynamics).

Honeycomb desiccant in many wheel-type dryers operates at a lower temperature than typical desiccant towers. (Photo: Novatec)

Use an aftercooler if your drying temperatures exceed 180 F. (Photo: Conair)

c. *Air temperature at the inlet of the desiccant.* You rarely see such a sensor, but molecular sieves and silica gel desiccants lose significant drying capacity above 150 F (65 C). Air temperature entering the desiccant should be below 150 F, ideally near 130 F (55 C).

d. *Temperature of the air going to the desiccant for regeneration.* An alternative is a readout of amps on the regeneration heater. It's nice to know those heaters are working and running at the right temperature. Alarm on this if it is not at the right regeneration temperature or amps. Wheel-type dryers need 350 F (175 C) for canister-bed type desiccant, or 400 F (205 C) for molecular sieves. Twin-bed desiccant towers need 550 F (287 C) if running on 4-hr cycles. Four-bed desiccant dryers need only 400 F (205 C) for 1-hr cycles. Temperature exiting the regeneration loop should be higher than 212 F (100 C).

3. **Specify and properly connect water to an "aftercooler"** if you will be using a drying temperature above 180 F (82 C).
4. **Check the volume of air the dryer will be circulating.** I believe this should be 0.6 ft^3 of air per pound of capacity
5. **Delivery of air to the dryer hopper should be forced to the lowest point where the plastic granules are.** Air will take the path of least resistance, which is upward. Often dry air does not get circulated down to the bottom of the drying hopper. This requires someone to drain it before processing begins and not all dryers make it easy for you to do this.

6. **Hoses going to the drying hopper should be insulated;** return-air hoses should not be insulated.
7. **Regeneration heater coils should have an indicator light measuring ohms.** If the resistance is not right, an alarm should beep or red light go on, indicating a regeneration problem. This alarm could also be based on inlet air temperature or low amps.
8. **Hopper loader should be piano hinged** with a one-step lock-down mechanism.
9. **All gaskets on doors, loaders etc. should be high quality, durable,** and work like a refrigerator or freezer door gasket—i.e., self-sealing upon contact.
10. **There should be filters** for fines, volatiles and oil.
11. **All filters on the dryer or aftercooler should have a pressure-differential indicator** with a

There should be air filters to trap fines, volatiles, and oil. (Photo: Wittmann Battenfeld)

Filters should have an alarm to indicate when they need cleaning. (Photo: Conair)

You want a dryer that distributes drying air at the lowest point in the drying hopper so that it reaches all the pellets. Shown here: the air-distributor drying cone. (Photo: Dri-Air Industries)

A 60° included angle on hoppers and spreader cones will ensure funnel flow instead of center flow ("rat-holing"). Doors should have gaskets that provide a tight seal to keep out moist ambient air.(Photo: Dri-Air Industries)

Continued on p. 18...

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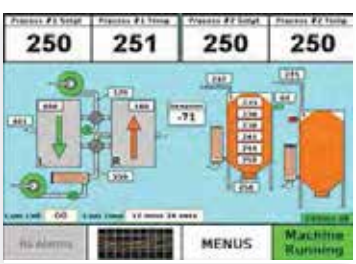

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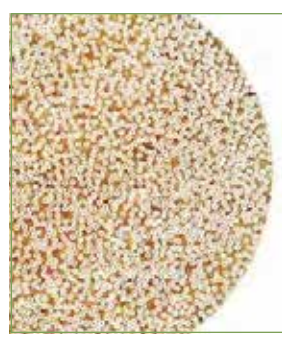
...*Continued from p. 14*

visual or audible alarm to inform floor personnel it is time to clean the filter.

12. **The dryer's controller should be** user-friendly and easily seen.
13. **All cone angles for hopper, spreader cone etc. should be 60° (included angle).** This is to avoid funnel flow and assure mass flow. If you get funnel flow, the resin will travel through the center of the hopper faster ("rat-holing") and not get the proper residence time at drying temperature. Also, resin on the sides of the hopper will stay there until the hopper is completely drained. For a video of this, visit my website, ***scientificmolding.com***.
14. **Have a dewpoint readout**, but please remember: A low dewpoint reading is good, but that does not mean your resin is dry, just that the air is dry and has the ability to dry your resin.
15. **It would be nice to ensure that the recently regenerated desiccant is not placed into the processing stream too early.** Regeneration often runs at high temperatures and the hot desiccant bed provides a brief temperature spike that could cause your pellets to stick together and clog the hopper exit port.
16. **Consider vacuum dryers,** as they are the most energy efficient.
17. **If maintenance is a problem in your plant, consider membrane-type compressed-air dryers, as they are the easiest to maintain.** Membranes last forever, and have minimal filter requirements. Filters may need to be changed once a year. PT

A dewpoint sensor helps ensure the dryer is producing dry enough air dry (Photo: Wittmann Battenfeld)

Vacuum dryers are an energy-efficient option to consider. (Photo: Maguire Products)



Membrane-type compressed-air dryers with a moisture-filtering membrane (shown) have low maintenance requirements. (Photo: Novatec)

ABOUT THE AUTHOR

John Bozzelli is the founder of Injection Molding Solutions (Scientific Molding) in Midland, Mich., a provider of training and consulting services to injection molders, including LIMS, and other specialties. E-mail john@scientificmolding.com or visit scientificmolding.com.

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feature

by james j. callari, editorial director

Raise the Bar on Drying: Savvy Processors Reveal Best Practices

No one would dry resin if they didn't have to. Unlike blending, for example, where novel material combinations

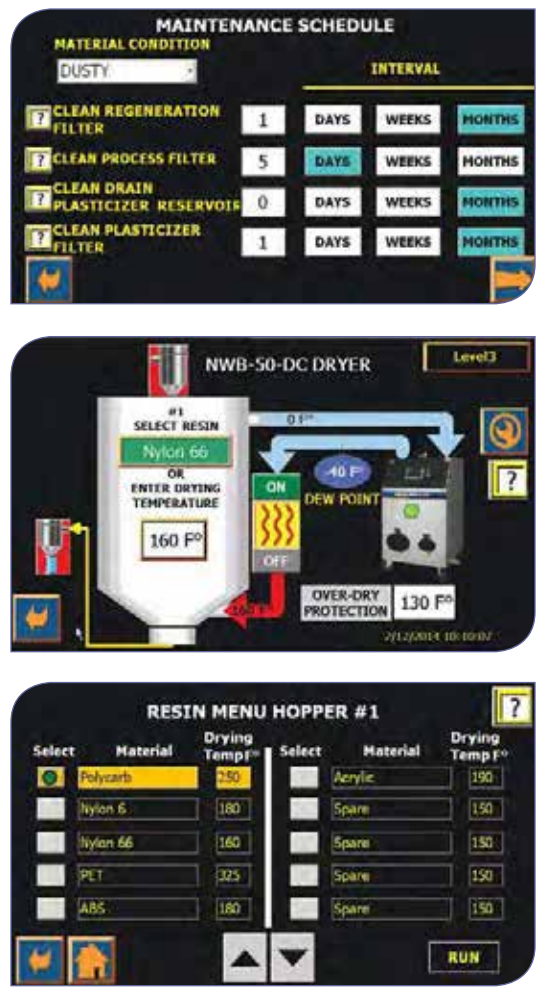
can boost part properties, resin drying doesn't add value to the process. But make no mistake: For processors running hygroscopic materials, getting this necessary evil right is the difference between making money or scrap.

Talk to 10 processors about "best practices" in drying, and brace yourself for 15 different answers. Despite its lofty position in the processing hierarchy of things that must be done right or else, drying is rife with anecdotes about fundamental flubs and oversights—even from seasoned molders.

The drying problem is not a question of adequate technology; indeed, resin-dryer technology has advanced on a regular basis for years. Says one Midwest molder, who spoke on condition of anonymity, "You can have the best dryers money can buy and still be bad at drying." The issue seems to involve an unwillingness of some processors to take the time required to understand the drying process—not just the intricacies, but the fundamentals.

One veteran processor who has been involved in several turnaround projects at various molding companies put it like this: "Drying is the most misunderstood and poorly applied process facing the industry today. I'm talking about fundamental things done consistently wrong."

This particular molder, who also asked to remain anonymous, recalls a humbling experience of his own. "I was working with a dryer that was



Dryer suppliers have tried to make setup, maintenance, and troubleshooting easier with more intuitive control systems. (Photo: Novatec)

operating just fine for a long time; then out of nowhere, it wasn't drying at all. We checked the beds, the filters, the connections, everything you could imagine. Nothing helped. So we called the supplier, and they sent a technician in the next day. He checked the same things we did. Then he asked for a ladder. He thought maybe the lid wasn't assembled properly. He climbed up and found the lid wasn't even on the drying hopper. Someone had removed it for cleaning and never put it back."

Making matters worse, as a result of downsizing caused by the economic downturn, some processors—smaller ones especially—have streamlined, if not eliminated, their manufacturing maintenance staffs. In some cases, they've shifted that responsibility to engineering. But engineers generally have other things to do beyond tending to dryers, so matters like checking filters, air flow, and desiccant beds get put off. And off.

Jeff Blake is manufacturing engineering manager for Parker Hannifin Corp. in Ravenna, Ohio, which extrudes hose and tubing for a wide variety of end markets, running nylons and TPUs, among other materials. He assesses the situation thusly: "Mom-and-pop molders tend to be concerned about making money on the parts they produce. That's understandable; but generally speaking, they don't spend a whole lot of time learning how a dryer works and how it must be maintained. Their mindset is, 'Here is my material, here is my mold, let me make a part for my customer and make money.' As a result, they won't think about changing a filter until the machine stops working."

The purpose of this article is not to compare various dryer technologies—multi-tower desiccants, wheels, vacuum, etc.—and suggest what might be best suited for your operation. Many of the bigger processing operations use combinations of multiple technologies. There are more desiccant-bed dryers in the field than any other type, but most processors agree that more wheel or carousel-style units have been purchased over the last five or six years. Vacuum units are currently available from only two suppliers: Maguire Inc., Aston., Pa. (***maguire.com***), and sister company Novatec Inc., Baltimore (***novatec.com***).

B&B Molders upgraded to a central drying system recently with Conair's Resin Works. The move allowed the molder to reduce a lot of its floor-drying activities. (Photo: Conair)

"We use both twin-bed desiccants and new wheels, based mostly on age, states John Patterson, divisional electrical engineer for injection molding plants at Delphi Packard, Vienna, Ohio. "We currently have dual-bed desiccant towers for our bulk dryers and we also use dual-bed units on the portable dryers. But recently we purchased a bulk wheel desiccant dryer (Novatec's NovaWheel NW 800) that sends desiccated air to four drying hoppers in one of our Mexican facilities.

"I like the new wheel dryer—it uses far less electricity and is very consistent from a dewpoint standpoint," Patterson elaborates. "However, our Mexico plant is up in the mountains about 4000 ft and the climate is dry and fairly consistent all year long. So I am really not testing or pushing the capability of the wheel dryer. I would like to have one in my plant in Vienna to see if it really works as advertised."

These remarks aside, this article is designed to offer some insights on how leading processors handle the big issues related to drying on a day-to-day basis.

ISSUE ONE: CENTRAL VS. FLOOR MOUNTED

Deciding whether to dry material at a central location and convey it to one or multiple machines, or dry it press-side, is one processors deal with almost every time they need a new system. Their decision is sometimes motivated by company culture. If, for example, floor-mounted drying happens to be a particular molder's "thing," that's tough to change. One molder, who molds 176 different types of materials, including a wide variety of ABS grades and

acetal blends, relies strictly on floor-mounted dryers furnished by Dri-Air Industries, East Windsor, Conn. (***dri-air.com***). He looks at the question pragmatically: "If I were buying a system to run 100,000 lb/week, I would centralize."

In some cases, the trend toward molding cells has influenced the decision to "stay local" on drying. Says Jerry Suchanek, tooling engineer for SSI Technologies, Janesville, Wis., which molds sensors for automotive and non-automotive applications using nylons, TPU's, acetal and other materials, "We currently use only floor mounted. We had considered going to a central drying system but because the molding in a lot of cases is within the manufacturing cell it wasn't as feasible." SSI currently has five E60-50/50/50 dryers from Wittmann Battenfeld, Torrington, Conn. (***wittmann-group.com***) The system combines the Drymax ES60 dryer will three hopper carts for quick color and material changes.

Kevin Skovira, manufacturing engineer at TE Connectivity (TE), Harrisburg, Pa., sees things similarly. This plant molds tiny interconnectors for appliances out of nylon, PBT, and LCP. He says, "We do at-the-press drying because we have molding cells. We're always changing things and find these systems to be the most adaptable." TE uses a portable system from Dri-Air called On-Demand Dry, Blend and Convey, in which virgin resin, regrind and colorant are processed on one system.

The decision to go central or floor-mounted is not always an either-or proposition. Some molders do both. Sometimes the choice is based on where the central drying system is located. To hedge their bets, savvy processors who dry centrally may also use a portable or even a throat-mounted drying hopper to guard against the possibility that resin may have picked up moisture during the conveying process.

Sometimes the decision to do both is material-specific. B&B Molders LLC, Mishawaka, Ind., recently installed a new Resin Works drying and conveying system from The Conair Group, Cranberry Township, Pa. (***conairgroup.com***). The system consists of three wheel-style dryers and 30 individually controlled Resin Works hopper stations, a handful of them dedicated to specific materials, and is designed to deliver high-volume resins to multiple machines.

One seasoned molder lets fresh desiccant sit for a bit in the tower and periodically taps on the side of the vessel to allow the desiccant to settle. Then he tops it off. (Photo: Dri-Air Industries)

"The central drying system is more flexible than the one it replaced, and we did have some discussion during the evaluation processes around central vs. floor-mounted drying," remarks Jim Krezel, B&B's manager of operations. B&B is a custom molder that runs ABS, PC, various nylons, SAN, and acetals for a wide range of industries. Notes Krezel, "Certainly, the central system eliminated what we did on the floor. However, when we are running clear materials for products that need to be light-reflective, we still dry on the floor."

B&B typically does as many as four to six mold changes per shift, and its decision to go central is a counterpoint to those who say floor-mounted systems are more conducive to molders who switch jobs a lot. "We pre-schedule everything," says Krezel. "We'll start the drying process three to four hours in advance of a job change, so when the new mold is in place, the material is ready as well."

Krezel adds, "The new system that we installed solved all of the problems that we fought in the past. Having properly dried material when we need it has been fixed. Having capacity to properly dry has

been fixed. Handling our regrind has improved dramatically, and today we utilize 100% regrind on products that can use it. Transferring material from material storage to molding and back is now extremely effective and seamless."

Delphi is another molder that combines central and floor-mounted drying. Delphi runs many different nylons, LCP, PPA, and other materials at its 47 molding plants. Its primary business is automotive connectors, but it also makes parts for tractors, cell phones, and other applications.

States Patterson, "We have what we call high-volume materials that are located in regional drying areas," he says, explaining his setup. "There are two regional areas in our facility that feed 60 machines each, and each regional area has 16 drying hoppers of various sizes ranging from 1200 lb to 400 lb, and these are controlled by a plenum bulk drying system.

"The bulk drying system is composed of dual-desiccant-bed towers that supply eight of the bulk drying hoppers with dry air. Each drying hopper also has its own process heater and blower motor. Each hopper is individually temperature controlled and we also monitor the dewpoint for each individual drying hopper, which is fed back to the main controller mounted on the bulk dryer.

"Each individual hopper also has (Novatec's) Moisture Manager control, which means we can block the dry air coming from the bulk plenum and just recirculate the air within the bulk drying hoppers. This way we can control the dewpoint and not over-dry the material. The bulk dryers can be switched based on time or dewpoint. So the eight hoppers are controlled by one bulk dryer, plus there is another bulk dryer wired as a backup dryer.

"The backup bulk dryer is wired such that we can instantly switch over to the backup if maintenance is needed on the bulk dryer that is currently

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online with the hoppers. The backup dryer is running and ready to go, because we wrote a program that keeps the beds regenerated offline and ready to go online at a moment's notice.

"Again, there are 16 drying hoppers in each region, so there are four individual tower bulk dryers. One bulk dryer provides desiccated air for eight hoppers, so two bulk dryers are on line at all times, and then there is a backup tower bulk dryer for each set of eight drying hoppers. So each region has four bulk dryers to handle the 16 drying hoppers."

Patterson adds that Delphi also uses what it calls low-volume (portable) dryers for low-volume materials. "The material is usually in a portable dryer somewhere next to a molding machine if it is not being actually used for a low-volume application. The portable dryer is actually on and running so the material in the dryer is dried. We have controls on the portable dryer to maintain a certain dewpoint level so we try not to over-dry the material, and when the material is needed it is already dry and ready to use. Once attached to a machine, the central vacuum system will pull material from the

Filter changes are a critical component of any dryer-maintenance program. Shown here is a process filter from a Novatec wheel dryer.

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portable dryer to the shot loader on the machine."

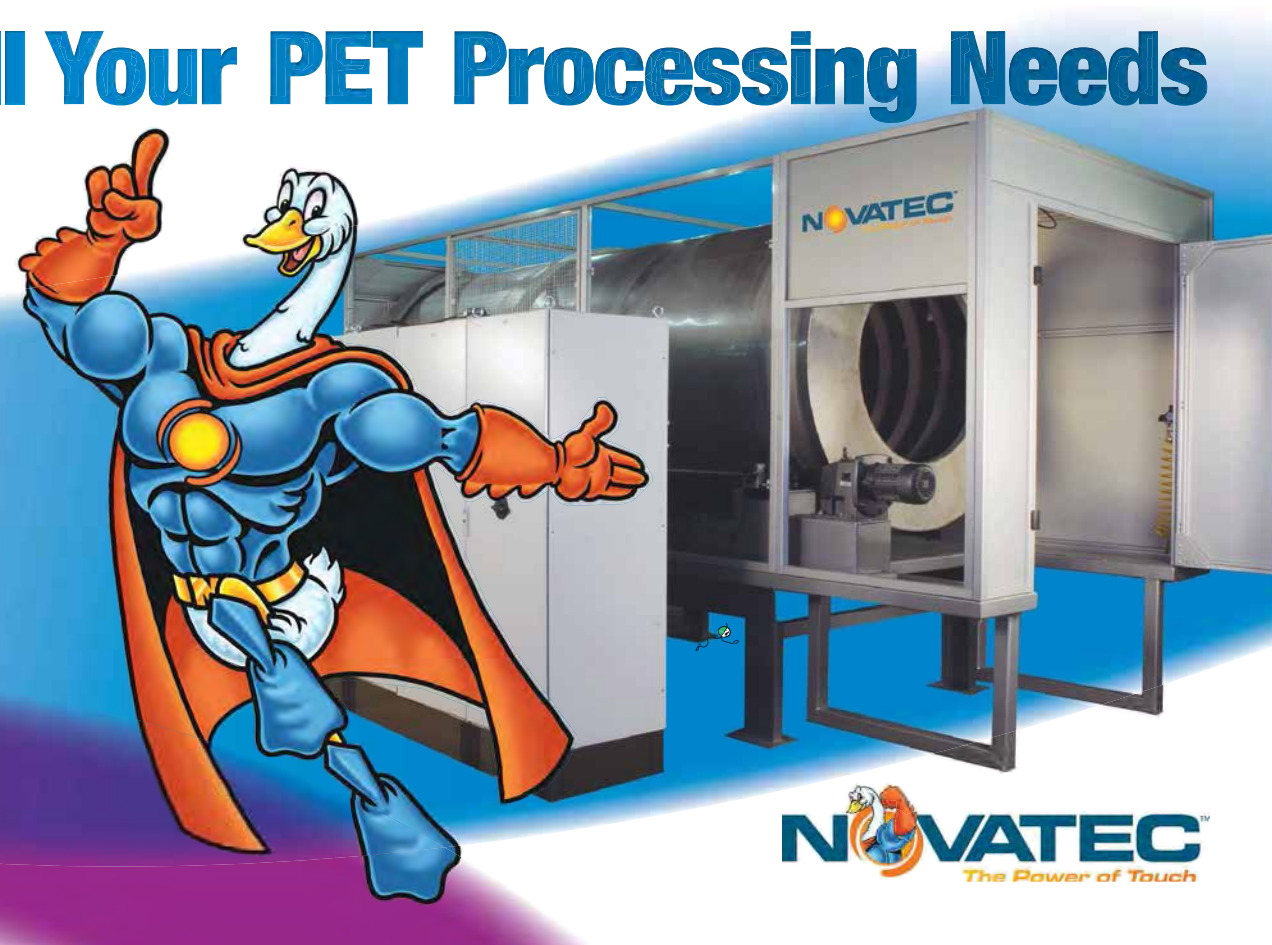
All the portable dryers—and the low-volume vessels that feed them at the press—are barcoded. "Upon downloading a new tool to the press, it will tell the mold setter that the material is bulk or low-volume," Patterson explains. "So the system knows what material is supposed to be utilized. Before starting the press, the operator must scan the bardcode on the tool, reject bin, grinder, molding machine, and dryer."

He continues: "The portable dryer information is stored in a database that says what material currently is in the dryer. If the material was to change in the portable dryer, it must go through a cleanout and be re-scanned at a cleanout station that tells the database the identity of this dryer and gives it a status of 'cleaned out,' so no material is designated for that portable dryer. Then, when the portable dryer is loaded again, the dryer is scanned with whatever material is put in that dryer at that time and the database is populated with that information. All the material types are also barcoded. So we know exactly what material is in what dryer at all times."

The portable dryers are loaded from low-volume vessels, which are 400-lb bins on rollers that are moved out to the molding press next to the portable dryer, Patterson explains. The portable dryer replenishes itself automatically based on level sensors on the hopper of the portable dryer. When the vessel is empty the signal is sent to the press and an alarm is noted on the machine's control screen telling the operator that the vessel needs to be replaced.

ISSUE TWO: DRYER SPECS & SIZING

Americans tend to like things bigger, and not just SUVs and hamburgers, but dryers too. Yet the feeling among processors is unanimous: Bigger isn't better in drying, and if you want to oversize to give yourself some flexibility for some future business



expansion, do so modestly.

"We started an energy-efficiency program six years ago," recalls a Midwest molder and extruder who asked not to be named. "We benchmarked our drying against a customer who also happened to be a molder. We found that we weren't making the connection between the capacity of our machines and the size of our dryers. Our dryers were too big. We were we over-drying the material and affecting part quality, and wasting energy. We found that 20% of our power was used by our drying process. In some jobs we were processing 4 lb/hr in a dryer with a capacity of 100 lb/hr."

This firm switched over to Dri-Air's Arid-X 10 Mini dryers and reports a 20% energy savings in kWh/press-hr even while its business was expanding.

At Delphi, Patterson's solution is to convey material to the presses using the dry air from the bulk dryers, and then send the material to small-shot loaders so the material does not spend a lot of time at the press and have a chance to gather moisture from the atmosphere. He adds, "Our plant is also temperature and humidity controlled so we don't have excessive moisture in the plant."

Patterson notes, "We have two different size portable dryers in our plant. One is for 50 lb/hr

The move toward molding cells has prompted some processors to stick with floor-mounted portable drying units.
(Photo: Dri-Air Industries)

throughput, and the other for 25 lb/hr. The size of the part and cycle time dictates which dryer is used in the low-volume case."

On the overall subject of dryer specifying, Patterson offers, "We generate our own set of specifications for portable and central dryers. We look at residence time and CFM of the dryers. We write our own program for the dryer so we basically can try different things and change the software to do what we want. We try to maintain at least 4 hr of residence time in the drying hopper as a rule of thumb. We tried different dryers in the past when we had a plastic lab. Vendors would give us a dryer and we did testing in our plant. We have offline moisture-testing units from Arizona Instruments (***azic.com***) and we would measure the moisture content of the material output based on putting in different levels of materials with different moisture levels."

States Blake "During the specification process, we look at pounds per hour required and the drying time and temperature for the application. I'd have to say throughput rate is typically the most important."

Adds another processor, "A great many molders miss the beat on matching dryer size to the shot size of the parts they are running. Whether you're running 3-4 lb or 25 lb or 1000 lb, you've got to size the dryer properly." This molder uses Dri-Air HPD portable dryers and also has larger floor-mounted dryers, model HP4-X 400, with 1500-lb drying hoppers.

Oversizing can also cause problems during molding. One global molder of medical and other technical parts from nylon, PC, acetal, and PEEK makes extensive use of cavity-pressure sensors. It found that material sitting in an oversized dryer would resorb moisture. The result was that all the cavities were not filling consistently. "Our strategy is to size to the press for the type of work we do: high-cavitation, small parts." This molder has 132

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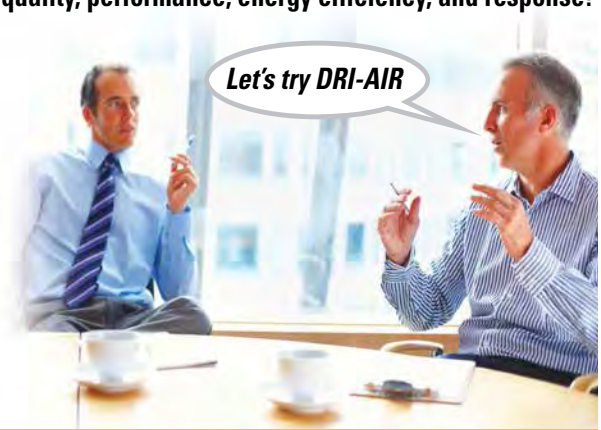

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floor-mounted dryers, most of them from Dri-Air, located below its presses. Dried resin is conveyed to molding machines with dry air. A purge valve located below the drying hopper keeps resin dry in the hopper and keeps the material line clear.

Delphi's Patterson adds, "We use shot loaders on every machine. The shot loaders are fairly small, and we feed the material to the shot loaders with dry air."

Suchanek has a similar approach: "We use extremely small hoppers mounted on the feed throat, almost like a single-shot loader, to reduce the amount of time material is exposed outside the dryer. We also try to keep the entire system as air-tight as is reasonable."

Adds B&B's Krezel, "On the molding machines, our system uses small hoppers sized for the press and small-shot hoppers that control material feed and flow to the press. It's a closed-loop vacuum system that utilizes clean, dry air in the conveying lines. This allows our material to remain dry during material transfers to the press, and the small hoppers allow for efficient use before moisture can return."

"We also look at air-flow capacity when comparing dryers, adds Patterson. "We look at residence time and, which goes back to throughput, and we also ensure the CFM is properly sized for whatever size drying hopper is mounted on the portable dryer or the bulk drying hoppers. The CFM is dependent on the height and diameter of the hopper. We always consult with the dryer companies to ensure we have the properly sized blower mounted on the system."

While there are more multi-bed style desiccant dryers in operation today, a growing number of processors have been buying wheel-style units over the last few years. (Photo: Shini)

Suchanek sums up the matter of dryer specifying: "I have always maintained that if one supplier were that much above the competition, then they would in essence be the *only* supplier. So for us it comes down initially to price and reputation/service when first deciding on a manufacturer. We have been trying to commonize to simplify, the goal being to only need to train for and maintain one brand."

Suchanek continues, "We typically size a dryer for a specific application. Based on the available features of the dryers we have specified, the throughput is adjustable so we allow ourselves the ability to buy somewhat larger hoppers where we custom-tune the throughput to the specified job."

Says Dave Spontik, technical service manager for Lubrizol's processing operation in Brecksville, Ohio, "We examine temperature capability, air-temperature control at the inlet to the hopper, airflow volume, low dewpoint, data monitoring, hopper design, ease of loading, ease of cleaning, closed-loop material transfer to the machine, and how easy it is to keep it functional."

ISSUE THREE: TRAINING

Is dryer training pursued by leading processors? The answer appears to be yes, but probably not enough. "Operators are trained to operate the equipment and to understand the drying requirements of the material," states Spontik of Lubrizol, which processes TPUs into footwear and performance apparel, film and sheet, electrical components, and an array of other products. "We also train on how the dryer is supposed to function and simple troubleshooting of the system."

Adds Suchanek of SSI, "We train our molding technicians to operate the dryers and to understand and perform what preventive maintenance is associated with it, which I think helps with troubleshooting. We emphasize material changes, making sure the dryers are clean to eliminate dissimilar materials from cross-contaminating. That's a big issue for us. Since we run multiple materials at one press, we need to ensure that the hoppers and loaders are completely clean of the previous material. It's not just the hopper but the hoses, loaders, filters, feed throats, and all those areas where pellets could be left behind."

Delphi handles things differently. "Operators basically answer alarms and don't touch the dryers," says Patterson. "They are essentially locked out from

changing setpoints. We have engineers on the floor who do startups and take care of machine problems."

ISSUE FOUR: MAINTENANCE

Skovira says TE has a large group of highly skilled electricians and has both preventative maintenance (PM) and total productive maintenance (TPM) programs. "We regularly look at wear items like desiccants. We check the purge system and the blowers, looking for trapped materials. We have our material handlers handle the filter changes."

Delphi's Patterson notes that his company has a separate maintenance group in the plant. "They will fix the dryers when certain alarms occur, like high dew-point, heater failures, and so on. We also have a PM program for both the bulk dryers and portable dryers."

SSI's maintenance program ultimately gets tied into its ERP program. Says Suchanek, "Initially we follow the dryer manufacturers' recommendations where maintenance is concerned. We input this information into our ERP system to generate the required work orders, and then add additional PM items as needed if we identify other potential areas of concern."

One seasoned molder, who happens to be the president of his company, doesn't always wait for his maintenance staff to check on how things are working. "I've always been a hands-on guy and I don't wait for maintenance to come to me. I'll walk around the plant periodically. I'll take my hand and run it around the circumference of the drying hopper, trying to feel for cold spots that might suggest something is preventing the dry air from drying the material uniformly.

"I'll go out and watch the operators change the desiccants. I've seen a lot of operators do this incorrectly," this molder adds. "They don't fill the desiccant beads to the top of the tower. When it looks full, what I do is take an object and gently tap on the side of the tower. If you do that, you'll see the desiccant start to settle, and then you can top it off."

Blake of Parker Hannifin weighs in: "Our biggest issues are having dryers that run and work consistently, keeping the filters clean, keeping the systems sealed up, and stopping air leakage. We have PMs to verify that the dryers are working consistently. We also have audits by employees that might not be operators to look at the drying systems."

Molder SSI has five E60-50/50/50 dryers from Wittmann Battenfeld. SSI combines the ES60 dryer will three hopper carts for quick color and material changes. (Photo: SSI Technologies)

At Lubrizol, a lot of effort is put into keeping dryers up and running to spec. Notes Roger Clement, technical service engineer at Lubrizol, "We're drying a variety of materials with different drying conditions that change the throughput rates. We inspect and audit our drying equipment before putting it in use. We use moisture analyzers to check pellet moisture. And we will use multiple dryers and hopper sizes to match the throughput and drying times needed for the specific job."

Adds Suchanek of SSI Technologies, "After the proper specs are set, the reliability of the overall system and its ability to maintain drying consistency day in and day out are the most important issues for us."

ISSUE FIVE: HANDLING THE BIG CHALLENGES

The drying issues processors face daily vary quite a bit, but there are a few common threads:

•*Regrind*: "We move our regrind from our beside-the-press grinder back into material rooms," says Patterson of Delphi. "In the material rooms we classify the regrind, then 'family blend' it with virgin, then send that out to the bulk dryers in the regional system.

"We try to use as much regrind as possible. We have done studies that show we can blend the regrind back in without degrading the material properties up to seven times. We feel the regrind is used up before it is recycled

Continued on p. 31...

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Dryer Controls
PET & Bioresin Processors
Drying Configurations & Installation
Maintenance
FAQ
Ask an Expert
Ask application engineers your specific question
Mark Haynie
Drying Product Manager
Drying Basics
Dehumidifying of plastics resin is utilized to minimize or eliminate problems that may be caused by too much or too little moisture in a plastic material during processing. Although most processors accept the need to predry resins, particularly highly hygroscopic ones, many do not understand the basics - or even the vocabulary of resin drying... more (+)
Resin Types
Each resin has a set of processing characteristics. They also have a certain affinity to collect moisture, which dictates the method and time required for drying... more (+)
Dryer Controls Today and "The Power of Touch"
In the past the industry's most advanced drying controls were only used in central conveying systems. More commonly used were microprocessor controls for dryers which varied in design from liquid crystal or vacuum fluorescent to LED displays. The more sophisticated controls were generally developed for conveying systems utilizing multiple receivers, pumps and material
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...*Continued from p. 29*

that many times. We blend regrind in different ratios based on how much we generate in the facility."

Adds Skovira of TE, "We have two main drying hoppers. One draws virgin material from the gaylord. The other is fed ground sprues and runners from a granulator close to the dryer. So we can control the drying parameters of the virgin and regrind separately."

•*Low-temperature drying*: Lubrizol's Clement offers, "Care must be used to avoid material blocking. Recirculation or stirring is sometimes used to prevent blocking of the softer materials."

•*Moisture pick-up in blenders*: Recommends Spontik of Lubrizol, "Avoid ambient-air blending if possible and minimize exposure time to ambient-air moisture. Agrees Blake of Parker Hannifin, "Try to limit dwell time in the blender."

SSI's Suchanek puts it this way: "We're only blending HDPE, so moisture isn't that much of a concern. If we ever had to go that route, my first choice would be to use a compounded material to eliminate the need for blending, otherwise we would need to ensure that we are blending in advance of needing the material so we have time to dry to the manufacturers' specifications."

•*Separation of blended material in a drying hopper:* Advises Clement, "Try to keep the pellet size the same, but this is not always practicable. Side feeders can eliminate this issue but would require another dryer."

•*Air-flow capacity:* Says Suchanek, "The larger hoppers we specify lend themselves to cost-effectiveness in regards to volume of drying air. Doubling air flow doesn't reduce drying time by half, but it doubles operating costs and increases initial capital outlay while typically only returning a 10-20% reduction in drying time."

•*Minimizing residence time:* States Patterson, "Material throughput to the molding machines is important. We try to schedule tools in the machines for certain material types so we don't exceed the drying-hopper residence time. If we happen to be running a lot of one material type, we will put some machines on portable dryers so we don't overload our bulk system."

•*When to add more capacity:* "When our volume throughput exceeds minimum drying residence time, we know we need more capacity," states Spontik of Lubrizol. "We use moisture analyzers to monitor pellet moisture levels."

Adds Patterson, "We can modify the software and control what material goes where based on what is needed at the time. A high-volume material can become a lower-volume material, so we can change out high-volume materials when needed. We haveextra portable dryers ready to go when needed."

Says Suchanek, "We know we need additional capacity when our changeover times and associated labor costs start to affect production changeovers and our ability to properly maintain the equipment." PT

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By John Bozzelli, Injection Molding Solutions

Bozzelli's Dozen Drying Tips

There's a lot to know about drying—enough to fill a book, at least. But for now, here are a dozen details you need to know, from seasoned injection molding consultant and Scientific Molding trainer John Bozzelli (see p. 12).

1. **Automatically monitor filter function** with a pressure-differential indicator. If you system does not have one, install one.

2. **Keep two sets of filters**, one set in use the other being cleaned. Clean with a vacuum, not an air hose. Do not bang the filter to clean it. If you dent it, fines will foul the rest of the dryer.

3. **Look into rigging up a thermocouple in the air feed just before the desiccant bed.** The air temperature going to the desiccant beds should be below 150 F. If you are running the dryer hotter than 180 F, you'll need to have an aftercooler on the return line (which should not be insulated) so the air is cooled for the desiccant. The ideal operating temperature for the bed is about 120-150 F (50-65 C).

4. **Check your regeneration heater elements regularly.** If they are not working properly, you won't regenerate (dry) the desiccant properly, and it won't dry your resin as it's intended to. Put an "idiot light" on the control panel that tells you if the amps drawn by the heater are to specification. Or, you can measure the air inlet temperature to the desiccant bed being regenerated—this should be the temperature required to dry the desiccant. If these two options are not practical for you, measure the air outlet temperature from the bed being regenerated. It must be above 212 F (100 C).

5. **Examine the desiccant.** Is it still active? Read the supplier's instructions and you may find a simple test that involves putting dry desiccant into a little bit of water and watching for a temperature rise. Desiccants can become contaminated or ruined by off-gases from processing certain resins. A general rule is to change the desiccant every 18 months.

6. **Look for leaks** at seals and crushed hoses.

7. **Don't bring the dryer on stream with newly regenerated desiccant before it is cooled down properly.** Otherwise you might wind up with a 200-lb pellet clump. With some dryers, you can get a slug of 350 F (180 C) air going into the drying hopper when the system switches desiccant beds.

8. **Measure dewpoint.** Run at less than -25 F (-32 C) dewpoint—better yet, a good dryer should run at -40 F/C dewpoint. The dewpoint of the drying air does not tell you if the resin is dry, just whether the air is dry enough to do the job.

9. **Test some dried resin for moisture content** to know if you are drying correctly. Use a moisture-specific method, not simple weight loss. Not all volatiles driven off a resin are water. Use Karl Fischer, dielectric, or other moisture-specific sensors.

10. **Do not convey dried material from a central hopper** to the machine, or leave it in the machine's hopper, without a blanket of dry air. Once dry, most resins will pick up moisture in 15 to 30 min.

11. **Note where the dry air enters the hopper and meets the resin.** Hot air will only travel upward, the path of least resistance. The bottom of the hopper is usually blocked. Therefore, any resin below the dry-air distribution hardware (look for a dip tube) must be drained and put back on top of the hopper load before you start molding.

12. **If you dry cellulosics, TPUs, flexible PVC, TPVs**, and some other soft-touch resins, check the desiccant's condition every six months, because these resins emit volatiles that can ruin desiccant.

BOZZELLI'S DRYING QUIZ

Three questions about drying plastics that everyone should know how to answer. Answers at the bottom. Don't peek until you've taken the quiz.

Q.1. Molecular sieves are often used in desiccant canisters to extract the moisture in the air circulating through the dryer. At what temperature should these desiccant canisters operate to keep the air dry?

Q. 2. What is the proper temperature needed to drive the moisture off the desiccant for regeneration?

Q.3. What is the only correct method for measuring moisture in plastics—weight loss or moisture-specific analysis?

ANSWERS:

Q1. Molecular sieves operate best at 120 to 130 F. Q2. For molecular sieves, regeneration temperature is 410 to 450 F. For cone ceramic type, 350 F. Q3. Moisture-specific is the only correct method!

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